EFFECT OF COLOR AND FLAVOR MODIFICATION ON THE PALATABILITY AND GEL STRUCTURE OF STANDARD BAKED CUSTARD

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ABSTRACT

EFFECT OF COLOR AND FLAVOR MODIFICATIONS ON THE PALATABILITY AND GEL STRUCTURE OF STANDARD BAKED CUSTARD

By Mary Evelyn Garlick

The purpose of this investigation was to study the effect of the addition of the nine possible combinations of three different peach colors and three levels of peach flavor on the palatability and gel structure of standard baked custard.

The basic formula contained a constant proportion of ingredients using reconstituted dried whole milk, fresh eggs and sucrose. Each of the nine treatment variables contained one of three peach colors - designated light, medium, and dark color - and one of three levels of peach flavor - designated low, medium, and high flavor level. A control custard having neither added color nor added flavor was used as a reference for the objective tests. Six replications of each of the nine treatment variables were prepared and evaluated at room temperature by subjective and objective methods.

A taste panel (4 women and 3 men) evaluated nine characteristics on a 7-point rating scale: crust color, crust tenderness, crust flavor, inside color, aroma, inside flavor, consistency, texture, and syneresis. Objective measurements included pH of the custard before and after baking, gel strength as indicated by the penetrometer (crust on, crust

off) and by per cent sag, and syneresis as indicated by per cent drainage.

Analysis of variance on the subjective scores for the nine treatment variables indicated no significant differences in six characteristics: crust tenderness, aroma, inside flavor, consistency, texture, and syneresis. The custards were significantly different in crust color (1% level of probability), inside color (1% level of probability), and crust flavor (5% level of probability). For crust color and inside color the medium color custards, as a group, scored highest. The custard with medium color and high flavor level scored highest for crust color and second highest for inside color. For crust flavor, the custard with medium color and high flavor level scored the highest followed by two custards containing the low flavor level and dark and medium colors respectively. There was an indication of the "halo effect" of color impression on the judges' scores for flavor. The judges' scores and comments indicated the color and the flavor were concentrated in the crust. In considering all three significantly different subjective characteristics, it appeared that the custard containing the medium color and high flavor level was scored highest by this taste panel.

No significant differences existed in any of the objective measurements. High standard deviations in the measurements for both gel strength and per cent drainage cast doubt on the reliability and suitability of these two objective measurements for baked custards. The addition of color and flavor did not alter the pH of either the mix or the baked custards as compared to the control custard.

No significant correlations were found between objective and subjective measurements for gel strength or for syneresis. The highly significant positive correlations between crust color and crust flavor and between inside color and inside flavor indicate further the "halo effect" of color impression on flavor judgment. Highly significant correlations existed between crust color and inside color, between crust flavor and inside flavor, and between texture and syneresis. Positive correlations (5% level of probability) existed between inside flavor and aroma and between consistency and texture.

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By

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1 Mention of manufacturers or their products in this thesis does not constitute endorsement by Michigan State University.

To my Mother and Father

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INTRODUCTION

For many decades home economists have been concerned with the importance of color and flavor of foods in the skillful planning of normal and modified diets. These food attributes have been recognized as important determinants of consumer acceptance and satisfaction. More recently, the research of psychologists and physiologists has reflected increased interest in and recognition of the effect food colors and flavors exert on the human appetite (2). Food technologists continue to focus their attention on the basic factors involved in the preservation of color and flavor in foods in the development of new processing techniques, new products, and new forms of established products.

Some dietitians have recognized the psychological impact of color as a key to successful meal planning and service (60). The appetite inhibiting effect of monotony in the diet is an ever present concern of all nutritionists. Although careful selection of food and food combinations is of prime importance, numerous workers believe that variation of color and flavor can be of considerable assistance in relieving monotony in all types of diets (2, 58).

The problem of monotony is, perhaps, more acute in the formulation of restricted diets than in the planning of normal ones, especially in the area of permissible dessert items. Baked custard, basically a soft, bland, high protein food consisting of milk, eggs and sugar, is used extensively for many types of modified diets. For the most part, when baked custards are served they are yellow in color and vanilla flavored. A search of the literature failed to reveal reports of investigations concerned with the use of fruit colors and flavors in the preparation of baked custards. If selected fruit colors and flavors could be added successfully to a basic custard formula, it is conceivable that variations of this standard dessert item would be useful to both the homemaker and the professional dietitian.

Preliminary experimental work indicated it is possible to produce a peach colored and peach flavored baked custard without noticeably altering the gel structure of the product. On the basis of these limited observations a controlled investigation was planned to study the effect of peach color and flavor modification on the palatability and gel structure of standard baked custard. The objectives of this study were:

1. To identify the types and proportions of food colors which can be combined with the natural carotene pigments present in a standard baked custard mix to produce a desirable peach color.
2. To determine the type and levels of peach flavors which, when added to the standard baked custard formula, produce custards of acceptable peach flavor compatible with the peach colors selected for study.
3. To study the effect of the addition of three

different peach colors and three levels of peach flavor on the palatability and gel structure of standard baked custard.

REVIEW OF LITERATURE

Color in Foods

<u>Importance of Color</u>

Color is constantly a part of food, a visual element to which human eyes, minds, emotions and palates are very sensitive. Through the ages, man has come to build strong and intuitive associations between what he sees and what he eats. People demand the right shade in foodstuffs and will accept or reject a product on its appearance - quite apart from nutritional considerations (2).

Color, the first quality attribute a consumer perceives, plays a major part in his willingness to accept a food. It is often regarded as an index of the general quality of the product, and may influence the consumer's judgment of flavor (28, 42, 57).

What is perhaps basic to color and appetite are certain direct associations and known responses to the stimulation of color. According to Birren (2), bright and "warm" colors (red, orange, and yellow) tend to stimulate the autonomic nervous system of man, including digestion, whereas soft and "cool" colors tend to retard it. Of these warm colors, red and orange have a more stimulating effect than yellow.

People learn to associate colors with various kinds of experiences with food such as their taste, odor, or the total complex of stimuli associated with eating, and ultimately with the resulting degree of satisfaction. However, to interpret preference for a food on the basis of color alone without regard to its role as a member of a group of stimuli could result in invalid conclusions (57).

Classes of Colors

The two general classifications of colors in food are natural and synthetic. The natural color classification includes the pigments and appearance factors actually found in food, such as the hemes, carotenoids, chlorophylls, anthocyanins, and flavonoids. Carotene is present in egg and milk and lutein is the yellow coloring matter of egg yolk (42). Natural colors also include those derived from vegetable, animal, and mineral sources. Natural vegetable colors most commonly added to foods are caramel, from burnt sugar, and annatto, an extract of annatto seed (60).

Synthetic colors are compounds of known structure produced by chemical synthesis and conforming to standards established by the U. S. Food and Drug Administration. Synthetic colors are most widely used in the food industries because of the variety of available shades, their brilliance and uniformity, solubility and high tinctorial strength (60).

Addition of Colors to Foods

Foods fall naturally into two groups when examined on the basis of color:

1. Foods which have an acceptable natural color, or in which an acceptable color is developed through cooking.

2. Foods which usually require added color in processing (margarine, cheese, desserts such as ice cream and sherbets, gelatin desserts, puddings, candy, cakes, cookies and pastries as well as many beverages) (60).

According to Jablonski (24), colors have long been used to improve the appearance of products. The number of coloring materials has increased in the past fifty years from a few simple ones to a vast range of tints and shades, mostly of synthetic production, and their use has become an integral part of our civilization.

U. S. government regulations

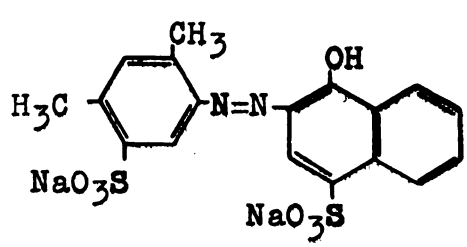
Added colors in foods are regulated by the Color Additives Amendment of 1960 to the Federal Food, Drug, and Cosmetic Act and are deemed "color additives" in the Code of Federal Regulations(10). In order to protect the health of the public, the U. S. Government permits food manufacturers to use only batches of coal-tar dyes which have been tested by the U. S. Food and Drug Administration and certified by this agency to be harmless and suitable for use (24).

Certified food colors

Jablonski (24) reports when the Federal Food and Drug Act was first enacted (1907) the number of permitted coal-tar colors certifiable for food purposes was limited to seven. By 1950 the number had increased to nineteen dyes - four oil-soluble dyes and fifteen water-soluble dyes. Since 1950 the Food and Drug Administration has removed the four oil-soluble colors and four of the water-soluble colors from the list of permitted colors because these delisted colors did not meet the requirements of the Color Additives Amendment of 1960 (10). At the present time there are eleven certified food colors, all of which are water-soluble (10). Most of the primary certified food colors have two names, the official or FD&C[1] designations and the common trade name.

FD&C Red No. 4 - Ponceau SX

FD&C Red No. 4, commonly called Ponceau SX, is a red powder easily soluble in water, giving an orange-red solution. In acid solution (pH 2.9) the color becomes very slightly redder. In alkali solution (pH 8.4) the color is not changed (24). Ponceau SX is the disodium salt of 2-(5-sulfo-2,4-xylyl-azo)-1-naphthol-4-sulfonic acid (10). Its structural formula (24) is:



FD&C Yellow No. 5 - Tartrazine

FD&C Yellow No. 5, commonly call Tartrazine, is an orange-yellow powder, easily soluble in water, giving a golden-yellow solution. There is no visible color change in either weak acid or weak alkaline solution (24). Tartrazine

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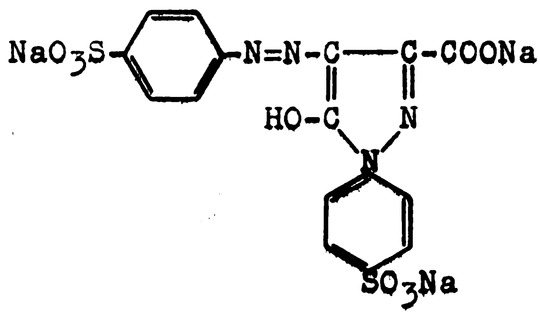
[1] FD&C signifies Foods, Drugs and Cosmetics and means that any certified color with this designation may be used in foods, in drugs and in cosmetics.

is the trisodium salt of 3-carboxy-5-hydroxy-1-p-sulfophenyl-4-p-sulfophenyl-azo-pyrazole (10). Its structural formula (24) is:



Color blends

Because the list of permitted colors represents a selection of shades far too limited to cover food industry needs, certified blends containing two or more permitted colors to produce numerous intermediate shades are available (60).

Evaluation and Measurement of Color

According to Brice (4), the measurement and specification of color is "color science" combining segments of physics, chemistry, physiology, and psychology for its complete understanding. With modern photoelectric instruments, and psychophysical data adopted by international agreement, the measurement and specification of color can be quite straightforward.

Although color evaluations may be made either by subjective or objective methods, there is considerable controversy as to the relative merits of each method in evaluating color in foods. Color evaluation in food products has become increasingly important as food technologists place more emphasis on product quality, yet color is one of the hardest quality factors to evaluate. To satisfy the desire for objectivity in recording colors and to overcome the shortcomings of the human eye in color perception, various instruments and devices have been constructed. Some instruments answered a need; others exchanged one difficulty for another. As color recording became mechanized, the interpretation of the data became more difficult (18, 56).

Subjective evaluation

Wilson et al. (62) state it is desirable to establish objective criteria which could be related to organoleptic evaluations. However, no specific criteria were given. Development of such quality indices would greatly alleviate the difficulties encountered in maintaining a trained panel of judges and eliminate certain variations due to fatigue in routine subjective testing of a large number of samples. The subjective methods of color measurement and standardization based on visual comparisons are subject to shortcomings of human observers, such as the variability in the reactions of different observers, and in those of one observer at different times and under different viewing conditions, and the unreliability of color memory. The difficulties associated with sensory testing have encouraged the development of objective methods for the measurement of color which eliminate the human retina in favor of the photoelectric cell (28).

Objective measurement

An objective evaluation of color may be made in a number of different ways, including the use of charts, discs, and instruments. Maerz and Paul's Dictionary of Color and the Munsell Book of Color provide charts for the visual comparison of colors. The Maxwell spinning disc principle has been used for color measurement for over 100 years. Available types of instruments for measuring color include: visual colorimeters, comparators, spectrophotometers, and tristimulus photoelectric colorimeters (52).

Robinson et al. (56) report the Maxwell spinning disc to be less objective than the photoelectric instrument, and its use is more tedious and time consuming.

The Hunter Color Difference Meter and the Gardner Color and Color-Difference Meter, which measure color directly by reflectance, have been used for color measurements in many research projects (5, 22, 34, 62, 63). Since the Hunter Color Difference Meter had been used successfully to measure color differences in tomato juice, strawberries, and other fruit and vegetable products, Huggart and Wenzel (22) undertook to determine if this instrument would be satisfactory for measuring the color of citrus juices and concentrates. They concluded that although color differences can be objectively measured with the Hunter Color Difference Meter, neither this nor any other instrument available at that time was satisfactory for determining the actual visual color of a citrus juice as seen by an observer.

Longree (36) found the Hunter Color Difference Meter unsatisfactory for evaluation of colors in baked custards. The subjective method of evaluating color was ultimately used in her study. According to Kefford (28), no one instrument to date has been devised by which it is possible to measure all the characteristics of colored bodies discernible to the human eye.

Flavor in Foods

Psychological Aspects

According to Meyer (48), flavor is the subtle and complex sensation that is the source of much of the delight man finds in food. To both connoisseur and layman, flavor is of utmost importance in determining preferences. One's appreciation of flavor and one's judgment are influenced by many psychological factors. Some of the psychological factors that cannot be controlled are the experience background of the individual and his personal problems and reactions (13, 48).

Pettit (54) states the psychological aspects of flavor include attitudes, experiences, memory, expectations, suggestions, motivations, and other factors of learned behavior. The setting, the questions, the personality and attitude of the investigator may all recall past experiences and influence the consumer's interpretation of his immediate flavor experience.

Flavor memories are very keen and enduring and must be taken into account whenever food flavors are being originated or changed. If the first meeting an individual has with a flavor is in medicine, there is a possibility that person will always dislike that flavor. Sometimes "innocent" flavors or textures such as those of oatmeal, cereal, cornstarch pudding, or jelly recall with great distaste some episode of sickness (12).

A person's reactions toward flavors are exceedingly characteristic and natural - a conservative person tends to be conservative in the flavors he likes. However, a person may train himself to recognize new flavors and to like them (12).

Sternberg in 1914 as reported by Crocker (14), states one naturally eats and swallows pleasant-tasting food rapidly, rather than lets them linger in the mouth. If one holds food long in the mouth, it is an indication the taste is not entirely a pleasant one.

Appropriateness is of great importance in our enjoyment of flavors in foods. An onion flavor may be delectable in a stew or soup but objectionable in a custard. We become conditioned to expect certain sensations from certain foods and while a slight variation is titillating, a completely unexpected taste is unacceptable (48).

Caul (7) has analyzed the pattern of good flavor as the following sensations: "(1) an early impact of appropriate flavor; (2) rapid development of an impression of highly blended and usually full-bodied flavor; (3) pleasant mouth sensations; (4) absence of isolated unpleasant notes; and (5) anticipation of the next mouthful."

Factors Influencing Flavor

Taste depends on a number of factors, the most important of which is chemical composition. Saltiness is a property of electrolytes, the halides in particular. Sweetness is found in a number of organic compounds, however, alcoholic hydroxyls are most effective in endowing a compound with sweetness. Bitterness is a property of some organic and inorganic compounds; some of the alkaloids such as quinine and brucine are exceedingly bitter. Sourness is a property of the hydrogen ion and its concentration is of primary importance in determining whether the sensation of sour is detected (48).

Taste is also influenced by temperature, texture, and the presence of other compounds. According to Crocker (12), temperature has a less noticable influence on the sweet and bitter taste components than it does on salty and sour components.

Texture properly is part of flavor; an unaccustomed texture places the senses of taste and smell under a handicap. Texture partially controls the quantity of sapid matter that can reach the taste buds at a given time; as a substance becomes thicker, the flavor becomes weaker. This weakening of taste is probably mechanical because the viscosity of the fluid interferes with the diffusion of the soluble substances to the sensory receptors (12, 13).

Mackey and Valassi (41) measured the taste threshold for four primary tastes (sweet, salty, sour and bitter) in water as well as in tomato juice and in egg-milk custard, prepared as liquid, gel, and foam. They found the primary tastes were hardest to detect in the gel state, easiest to detect in the liquid state, and intermediate in the foam.

The presence of other compounds has been shown to influence flavor in different ways. According to Pangborn (53) the interactions among taste qualities in foods have been a subject of opinion and speculation with relatively little experimental support. The early literature on the subject of taste interrelationships in aqueous solutions of pure compounds is controversial since conflicting results were obtained from similar experiments.

Results of studies on apricot, peach, and pear nectars carried out by Valdes et al. (59) show that sucrose enhanced fruit flavor up to an optimum sweetness level, beyond which it masked flavor. This relationship between sweetness and fruit flavor was found to be greatly influenced by the acidity of the product.

Addition of Flavors to Food Products

Flavoring extracts are widely used in the food industry and are well standardized in the United States. The standard for a flavoring extract, as established by the Secretary of Agriculture in 1919 and accepted by the flavor industry, is as follows: "a solution in ethyl alcohol of proper strength of the sapid and odorous principles derived from an aromatic plant, or parts of the plant, with or without its coloring matter, conforming in name to the plant used in its preparation". If artificial coloring or synthetic flavoring compounds are added, these must be declared on the label (23, 48).

Flavoring agents are chemical substances which are able to impress themselves on the senses of taste, smell, and feeling by way of food and drink. These chemicals are of many types and origins; some occur naturally in foods; some develop within food while it is being cooked or otherwise processed; and others are added substances of natural or artificial origin. Nearly all of the flavoring chemicals that have been identified in foods have been duplicated synthetically and, in many instances, these synthetics have been used in flavors (12, 14).

Imitation food flavors are composed of synthetic organic aromatic chemicals sometimes used alone or in combination with natural products. These chemicals can be used as food flavors for controlled accentuation of a particular note or notes, where a highly concentrated flavor is required and for economy (25).

From birth, modern generations have been reared and accustomed to accept taste trends, and flavors are a daily and accepted necessity in life. The desire for a variety of palatable and appetizing taste sensations that makes the consumption of food a pleasure, not a necessary daily task, is a basic consumer characteristic of our times (25, 46).

Literature with regard to food flavors has been very meager during the last fifty years, according to Merory (46). During this same period of time numerous compounds have been synthesized which are useful in formulating synthetic or imitation flavors. Such compounds are known as flavormatics and there are over 200 such flavormatics available for use in imitation flavor compositions (25, 46). In 1963 the Flavoring Extract Manufacturers' Association issued a new list of flavoring ingredients suitable for use in the preparation of imitation flavors (16).

Fruit Flavors

The skin and the peels of fruit carry most of the flavor. There is a correlation between sugar content, color, acidity, and flavor as fruit ripens. The flavor usually develops to its fullest when the sugar content of the fruit is at its maximum and the color of the skin or peel acquires the richest shade of brilliance (46).

Classifications

There are several types of flavoring materials available for use in food products. Legal definitions of these flavoring materials are lacking and the issues of "Imitation" and

"Natural" flavors are being discussed at the present time by governmental agencies and the flavor industry (16). The flavor industry and unofficially the F.D.A. accept the following definitions:

<u>True Fruit Flavoring</u> - extracts or concentrates derived directly from a particular aromatic plant or fruit, of which a minimum of 25# of fruit are used to yield 1 gal. of juice (16).

<u>True Fruit with Other Natural Flavors</u> - fruit flavors which are fortified with other natural flavors. At least 51% of the flavor strength must be derived from the true fruit named and not more than 49% from other natural flavors (23).

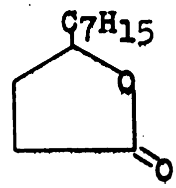
<u>Imitation Fruit Flavoring</u> - flavorings synthesized entirely from chemicals. There are no standards set for these flavorings, except that their constituents are to conform with the Food Additives Amendment of 1958 (16).

<u>Imitation Fruit Flavoring with True Fruit</u> - a combination of synthetic ingredients and true fruit extractives in which not less than 5% of the total flavor is derived from true fruit extractives (16).

<u>Peach Flavor</u>

The peach was one of the first fruits to be studied in order to determine the chemicals responsible for the flavor of the fruit. Power and Chestnut (55) state peach oil or peach essences consist for the most part of purely empirical mixtures of esters and essential oils with other more specific aromatic substances. The general character of these empirical mixtures indicates some of their components may not actually be found in the pulp of the fruit whose flavor they are supposed to represent. For example, benzaldehyde is frequently regarded as one of the proper constituents of peach aroma, although this is contained in the kernels of the peach and not in the pulp of the fruit.

Toward the end of the 19th century, the flavoring properties of gamma-n-heptyl butylrolactone were discovered and the chemical was synthesized. This became known as Aldehyde C-14 which is a misnomer, since it is neither an aldehyde nor does it contain 14 carbon atoms (27, 47). The formula for Aldehyde C-14 is:



According to Merwin (47), once the existence of gamma undecalactone became known, it became relatively simple to prepare a flavor resembling peach. It is difficult for any flavorist to conceive of a peach flavor today which will be acceptable to the American public without Aldehyde C-14. Besides gamma undecalactone, those ingredients which would be considered essential to peach flavor are benzaldehyde, some of the linalyl esters and several valeric acid esters (47).

Many foods can be flavored or reinforced with a peach flavor by using the proper level of gamma undecalactone and adjusting the color and acidity of the food product involved. Great care must be exercised because of the ease of over-flavoring and obtaining an objectionable flavor (47).

Custards as a Medium for Experimental Work with Color and Flavor

Baked custard represents a type of cooked product in which the thickening property of the egg protein is used, since only 0.75% of the heat coagulable protein is provided by the milk (38). Color, flavor, and odor are also detected easily in custards as they are made of relatively few essential ingredients (44).

Composition

Custard is made from milk, eggs, and sugar and sometimes salt and vanilla flavor. The same proportions of ingredients can be used for both stirred and baked custard (20). The baked custard is firmer than the stirred custard and appears to be in one piece or clot. All custards are highly sensitive to slight modifications in the egg-sugar-milk mixture.

Heat Coagulation of Proteins

The formation of a gel in custards depends on the coagulation of protein which then holds within its structure the solution from which it was precipitated (51). Although protein may be coagulated by many means, heat has been one of the most important methods. Heat coagulation of the egg and milk proteins in custards may be influenced by acid, alkali, salts, and organic solvents, as well as other factors (3, 38, 51).

Effect of Acid, Alkali, Salts and Organic Solvents

Weiser (61) indicates that certain protein sols (albumins, globulins, and globins) coagulate at some definite temperature which is fairly constant for each protein. With the lowering of the pH by the addition of acid, the coagulation temperature is raised. Chick and Martin (8) point out denaturation, the first part of the heat coagulation process, is not hastened by acid solution, but the clotting or coagulation process is accelerated. The second part of the coagulation process, the clotting or coagulation, does not occur in alkaline solution. If, after heating, the alkali is neutralized with acid, the coagulation process occurs (9).

Although the salt content of milk is low, it is very important in the behavior of the proteins in food preparation (38). A good example is custard, which fails to thicken when heated unless sufficient salts are present. Lowe (38) reports the concentration of the salt and the valence of the ion have an effect on the coagulation of custards. Chick and Martin (8) state an increase in the concentration of salts raises the coagulation temperature. Many anions such as iodide, bromide, and chloride are denaturing agents (48); however according to Fruton and Simmonds (19), not all anions are denaturing agents - caprylate and aromatic carboxylate ions actually protect egg albumin from heat denaturation.

Denaturation may be caused by organic solvents such as ethanol, methanol, and acetone. These have been used for the precipitation of proteins from aqueous solutions (19). There is a decrease in the protein stability of milk toward alcohol as a result of homogenization, according to Carr and Trout (6).

pH of Custard Mix and Cooked Custard

The pH of the eggs used in custard has an effect on the pH of the custard mix - fresh eggs are less alkaline than aged ones. Cooked custards are usually more alkaline than the custard mix (3, 35, 38). Bittner (3) reports the pH readings on the custard mix and baked custard made with fresh eggs and dried whole milk as 7.03 and 7.09 respectively.

Gelation Temperature and Rate of Cooking

Many factors affect the coagulation of protein and the gelation temperature of custards. These factors include the proportion of ingredients, the pH of the mixture, and the rate of cooking. As a result, no one internal end temperature can be recommended as the optimum temperature to which a custard should be baked. Lowe (38) states with ordinary rates of cooking, and using unhomogenized milk, a serving consistency for custard is usually obtained between 82° and 84°C. Carr and Trout (6) state the rate of heat penetration is slower in custards made with homogenized milk than in those made with unhomogenized milk. The firmness of the custards indicates the custards prepared with homogenized milk could be baked to a higher internal end temperature without seriously affecting the stability of the gel. Miller et al. (49) observed the optimum gelation temperature of custards prepared from fresh shell eggs and homogenized milk to be 86° to 88°C. Cook and Husseman (11) state the temperature required to reach gels of similar consistency is 1°C higher when dried whole milk is used instead of fresh whole milk.

Lowe (38) reports the rate of coagulation increases as the oven temperature is raised; in addition, a firmer custard is obtained as the temperature is increased until at a specific internal temperature, dependent on the rate of cooking, optimum gelation occurs. Further heating to a higher internal temperature causes porosity and finally syneresis.

Experimentation shows the rate at which custard is cooked affects the gelation temperature - with a slow rate of cooking, gelation of custard occurs at a lower temperature, while gelation takes place at a higher temperature with a fast rate of cooking. A slower rate of cooking is considered most desirable because optimum gelation is more easily perceptible (38).

Method of Baking

Two factors to consider in baking custards are the oven temperature and the temperature of the water bath. Griswold (20) states even when baked at relatively low oven temperatures, custards are improved by being placed in a pan of hot water for protection from oven heat. Bittner (3) and Carr and Trout (6) used an oven temperature of 325°F in their research work with custards. McBride (45) and Mastic (44) regulated the oven at 350°F. Jordan et al. (26) report an oven temperature of 350°F is preferred to 325°F or 400°F because the baking period is unduly long at 325°F and so short at 400°F that the custard can easily be overcooked. In addition, custards baked at 400°F are reported less desirable in appearance than those baked at the other two temperatures. To insure the relatively long heating which is necessary to make the food product bacteriologically safe, it is recommended that an oven temperature of 350°F or below be used for baking custards (37).

For many years the recommended initial temperature for the water bath for baked custards has been boiling or hot water. Various initial temperatures have been reported for the water baths used in research work on custards in the past few years: Bittner (3) used 35°C, Carr and Trout (6) used 30°C, and Mastic (44) used 25°-27°C. Nagler (50) reports the texture of the custards was more delicate and tender if the initial water for the baking pan was 35° to 40°C rather than 97° to 100°C. The results of a special problem undertaken by the writer at Michigan State University in 1963 on the hot water bath versus the cold water bath for baked custards indicated that custards started in a 20°C water bath were superior to those started in a 40°C water bath for the following characteristics: inside appearance, crust tenderness, texture, flavor, consistency, syneresis, and general acceptability.

Use of Dried Whole Milk in Baked Custards

Bittner (3) reports the results of using dried whole milk (DWM) in place of other milks in baked custards, all of which were baked to 86°C. Baked custards prepared with DWM were similar in appearance to custards made with homogenized milk or with pasteurized milk, however the crusts of the DWM custards were slightly more wrinkled and less tender than those made from homogenized milk. The inside color for the DWM custards scored slightly higher than when homogenized or pasteurized milk was used. The DWM custards had a highly significantly different flavor than pasteurized milk custards - a decided cooked flavor was indicated and the DWM custards were significantly sweeter than those made with pasteurized milk. The DWM custards were firmer than custards made from homogenized milk but less firm than those made from pasteurized milk.

Evaluation of Foods

Food products can be evaluated by either of two methods: the subjective method in which a particular characteristic of a product is scored or otherwise rated by an individual with a score being decided upon by judgment, or the objective method where the outcome is largely independent of human judgment (43).

Although the limitations of a taste panel for judging the palatability or eating quality of food are realized by investigators, there are still organoleptic factors which cannot be expressed by objective measurements. Factors such as appearance, color, and flavor are better judged by a scoring panel. Results of objective tests may often be correlated with results obtained by subjective means (3, 44).

Lowe and Stewart (39) state it is desirable to employ both subjective and objective tests in connection with research on the functional and organoleptic properties of food products. During the development of an objective test it is particularly appropriate to run parallel organoleptic tests in order to test the degree of correlation between them.

Subjective Methods

Subjective tests measure the qualities of food as they make their impression individually and collectively on the sensory organs. They are subjective because the individual is required to go through a mental process in giving his opinion as to the qualitative and quantitative value of the characteristic or characteristics under study.

Types of tests and judgments

According to Lowe and Stewart (39), subjective tests may be conveniently classified into 2 categories: a) preference or acceptance tests and b) psychometric or difference tests. In preference testing the degree of acceptance is obtained and, when conducted with a large enough number of people within a population, permits the determination of consumer acceptance of a product.

The psychometric tests are for determining quantitative differences, such as rating or scoring food quality factors. They can be used to evaluate quality differences among breeds, varieties, or formulas. This makes these tests valuable research and development tools (39).

Mason and Koch (43) state that two reasons for choosing a scoring system in preference to a ranking system where the treatments are ranked according to a preference for a given product are:

1. a scoring system permits ties, whereas a ranking system forces judgment even though the taster can detect no definite difference.

2. a scoring system permits the spread of treatments to be influenced by the magnitude of the differences found. If there are very distinct differences between two samples, one may be scored 1 and one scored 10, but in ranking they must be 1 and 2.

Often a numerical scale is used so that the scores of the individual taste panel members can be added readily to give a composite score (48).

Considerations for taste panels

Owing to practical considerations, most panels are composed of from four to twelve members and if only three or four acceptable judges are available, results comparable to those of a larger panel can be obtained if each sample is scored two or three times during the investigation (20, 30, 39).

According to Dawson et al. (15) a panel of three to ten is usually adequate for testing flavor differences but panel size depends on the variability associated with the experiment and on the magnitude of the difference between samples to be detected.

Experimental work by Langwill (33) indicates that women between the ages of seventeen and thirty years of age have a greater sensitivity of taste in distinguishing between sweet, salty, sour, and bitter foods than do men in the same age bracket. Laird and Breen (32) report from their study that, in comparison with men, women at all ages have more preferences for tart tastes, and less for sweet tastes.

The age of the judge is also a factor. Young people can distinguish differences between different strengths of sweet, sour, and salty food when middle-aged people cannot (1). Sensory ability decreases with age and preferences change also. Because of this it is felt that taste panel members should be between the ages of twenty and fifty (31).

<u>Objective Methods</u>

Types of objective evaluations are many and varied, including chemical, histological, and physical tests. Griswold (20) states objective methods are reproducible and less subject to error than sensory methods.

There are many examples in the literature of objective tests for measuring such varied acceptance characteristics of foods as texture, color, tenderness, consistency, and juiciness (39). There is no objective method for measuring flavor *per se*. However, some flavor components may be measured by chemical means, i.e., sugar, salt, and acid.

According to Lowe and Stewart (39) objective tests possess obvious advantages with respect to reproducibility and in the ease of applicability to the needs of the research laboratory. However, the ultimate test of whether an objective test is measuring a quality is its agreement with results of subjective testing (20).

EXPERIMENTAL PROCEDURE

Preliminary Investigations

Preliminary experimental work with the addition of food colors to baked custards indicated the possibility of developing in baked custard several pastel colors typical of different varieties of fruit. Strawberry, raspberry and peach colors were shown to be feasible, and of these, peach showed the most promise.

The kinds and amounts of food colors required to produce a peach color in baked custards were determined in this preliminary study. Various combinations of FD&C Red No. 4 and Yellow No. 5 were found to yield the most satisfactory range of tints and shades of peach color in baked custards. An arbitrary decision was made as to the color range selected for study. Two randomly selected preference panels of twenty persons each indicated which of these colors would be most acceptable in baked custards.

After the colors were established, various types and amounts of peach flavors individually and in combination were tried in the baked custards. On the basis of the trial tests, an arbitrary decision was made as to the flavor character and strengths that would be included in the study. A randomly selected preference panel of twenty-two persons evaluated custards containing three different combinations of peach flavors and indicated that all three combinations were acceptable.

Design of Experiment

Baked custards prepared from a standard formula with the addition of all possible combinations of three different peach colors and three levels of the same combination of three peach flavors were compared subjectively and objectively. A control custard having neither added color nor added flavor was used as a reference for the objective tests.

Color-Flavor Combinations

The nine treatment variables (A through I) represent all possible combinations of three different peach colors and three levels of the same peach flavor.

	Color			Flavor Level		
Variable	Light	Medium	Dark	Low	Medium	High
A	X			X		
B	X				X	
C	X					X
D		X		X		
E		X			X	
F		X				X
G			X	X		
H			X		X	
I			X			X

Quantities of the colors and flavors for the nine treatment variables are presented in Tables 20 and 21, pages 88 and 89 in the Appendix.

Six replications of each of the nine color-flavor combinations were prepared and evaluated. The baked custards were cooled to room temperature by a standard procedure before evaluation. Objective tests were conducted the first three weeks of the experiment and the subjective tests were conducted the following six weeks. Certain of the objective tests were performed daily on custards made from the same mix used for panel evaluation. This procedure was followed as a check against the objective tests previously conducted.

Four treatment variables[1] were prepared each day for the objective tests and baked in two batches. Sixteen custards, eight each of two treatment variables, were baked at one time. Of these eight custards, seven were used for objective tests and one to obtain a time-temperature record during baking.

For the subjective tests, three treatment variables were prepared each day in two bakes. Sixteen custards were baked at a time. In the first bake four custards of each of the three treatment variables were used for the taste panel, one custard of each of the three treatment variables was reserved for color determination, and one custard used to obtain a time-temperature record during baking.

The experiment had to be modified with respect to the objective determination of color. Due to mechanical

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[1] In this manuscript, treatment variable refers to a single color-flavor combination.

difficulties it was impossible to collect reliable data, therefore no further comment will be made on this point.

A predetermined randomized arrangement was used for the preparation of the treatment variables throughout the experiment and for the order of presentation of the samples to the judges each day. The weakest flavored custard in a group was always presented first to the taste panel.

Room temperature and humidity in the experimental foods laboratory were recorded on each day that custards were baked and evaluated[1].

Basic Custard Formula

The formula selected for study, based on that of Lowe (38) consisted of 3815 grams of reconstituted whole milk, 748 grams whole egg and 391 grams sucrose. Percentages of ingredients, based on total weight of the mixture, were: whole milk, 77.0; whole egg, 15.1; and sucrose, 7.9. The percent ratio of dried whole milk to water was 12.6 to 87.4.

Ingredient Procurement

Basic Formula Ingredients

A common lot of dried whole milk was prepared to specification by the Michigan State University Dairy Plant. The reconstituted milk contained 3.2% butterfat. The dried whole milk was packaged in small sealed polyethylene bags,

[1] Hygro-Thermograph, Model 594, Friez Instrument Division, Bendix Aviation Corporation, Baltimore, Maryland.

each containing 504 grams, and refrigerated at 38-40°F until needed. The dried whole milk was removed from the refrigerator and brought to room temperature before reconstitution.

Fresh eggs were obtained from a designated flock of White Leghorn hens at the Michigan State University Poultry Farm. The eggs used were fresh daily. Egg yolk color determinations were made at the beginning and in the middle of the experiment. The Cargill-Nutrena Yolk Color Meter readings were 5-6. The Heiman-Carver Yolk Color Roter determinations were 11-12 on all samples tested (21).

A common lot of sucrose, obtained from the Michigan State University Food Stores, was packaged in closed polyethylene bags, 391 grams per package, and stored in a covered metal container at room temperature.

Colors

The FD&C certified food colors were obtained from Food Materials Corporation in dry, powdered form and stored at room temperature in their original glass containers.

Flavors

In the preliminary work no single peach flavoring material imparted a satisfactory peach flavor to the baked custard. It was necessary to use combinations of peach flavoring materials. A combination of three different peach flavoring materials was selected. A description of the flavors and the quantity used are found in Tables 20, 21, and 22, pages 88, 89, and 90 in the Appendix. The flavoring materials were used full strength as received from the manufacturer.

Preparation of Color Solutions

For addition to the custard mix, three color solutions (light, medium, dark) were prepared by dissolving varying proportions of FD&C Red No. 4 and FD&C Yellow No. 5 in distilled water. The weights of the two colors used in each of the color solutions are found in Table 23 in the Appendix.

Preparation of Custard Mix

Each day 4500 c.c. of the basic custard mix was prepared. The detailed procedure for the preparation of the custard mix is given in Exhibit 1, page 92 in the Appendix. Fresh, shell eggs were broken out, blended, and weighed. One package of pre-weighed sucrose was added to the eggs and the mixture blended. The reconstituted milk was added to the egg-sugar mixture and the entire mixture was blended. The custard mix was strained through a medium-fine, wire-mesh household strainer to remove unmixed material prior to the addition of color and flavor.

The basic custard mix was divided into smaller portions for addition of color-flavor variables. For the objective tests the basic mix (4500 c.c.) was divided into four portions of 1100 c.c. each. For the subjective tests it was divided into three portions of 1500 c.c. each.

All mixings to incorporate colors and flavors were done on Hobart K-5A mixers equipped with 5-quart stainless steel bowls and a paddle attachment. Portions of each final mixture reserved for the second bake were left at room temperature in the mixing bowls and covered with polyethylene coated freezer paper secured with a rubber band.

Baking Procedure

The custards were baked in 5-ounce pyrex custard cups. Each cup was filled with custard mix to a measured depth of 1 3/4 inches (approximately 130 c.c. custard mix). The cups were placed in a specially designed galvanized water bath pan equipped with a bronze stopcock for drainage and a perforated stainless steel sixteen-hole rack to support the cups (Figure 1). The cups were placed in a predetermined randomized order for the subjective and objective tests.

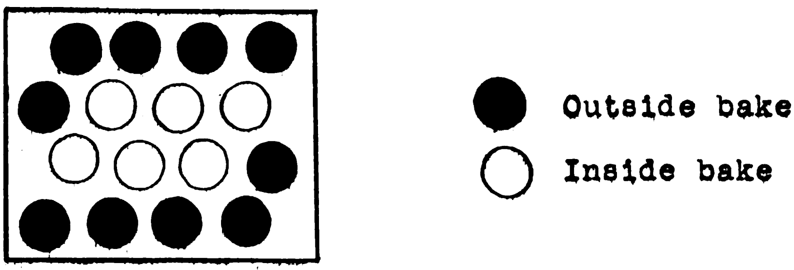
Water at 18-20°C was added to the pan until it came up to the level of the custard mix. The baking pan was placed on an oven rack 3 7/8 inches from the bottom of an apartment size General Electric Oven preheated to 350°F. Three lead wires from a Brown Electronik Potentiometer High Speed Multiple Point Recorder were clamped in place. One thermocouple was centered in a custard located in a central position of the baking pan, a second was positioned in the water bath just to the right of the custard containing the first

Figure 1. Water [illegible] equipped with potentiometer [illegible] perforated stainless steel rack, [illegible] of thermocouples.

thermocouple. The third thermocouple recorded the temperature at the center of the oven. All custards were baked to an internal temperature of 86°C. The oven was turned off and the water partially drained out of the water bath pan through the stopcock. The rack containing all the custard cups was then removed from the water bath pan. The oven was again preheated to 350°F and the second bake was carried out following the same procedure as the first bake. The custards were placed on wire racks and allowed to cool at room temperature for approximately three hours before objective or subjective tests were conducted.

Subjective Tests

The samples for the subjective tests were selected so that, in the course of six replications of each variable, each judge had an equal number of samples from inside bake and outside bake positions (see diagram below) as well as front and rear oven bake positions.



The panel was composed of 7 judges (4 women, 3 men) from several related departments of the university. A one-hour training session was held for all taste panel members at which they were given instructions as to how the samples would be presented, how to score the factors and the characteristics of a good baked custard. A sample of the instruction sheet is shown on pages 94 and 95 in the Appendix. To acquaint the taste panel members with peach flavor, several brands of peach ice cream were tasted.

The taste panel evaluated the room temperature custards for nine characteristics; crust color, crust tenderness, crust flavor, inside color, aroma, inside flavor, consistency, texture, and syneresis. Three different custard variations were scored each day. The custards were presented one at a time and the panel was requested to evaluate each sample individually without comparison with the other samples.

A 7-point rating scale was used in the evaluation with 7 as the highest score. The panel was instructed to score each custard on all nine characteristics and to check the most appropriate descriptive terms for those factors they scored 4 or below. A sample of the score sheet is shown on page 96 in the Appendix.

Objective Tests

On the day of preparation, objective tests were made on the room temperature custards to determine the gel strength, measured both as the ability to resist penetration and as the ability to hold a rigid shape; syneresis; and pH.

Continuous recordings of room temperature and relative humidity were made during each test period.

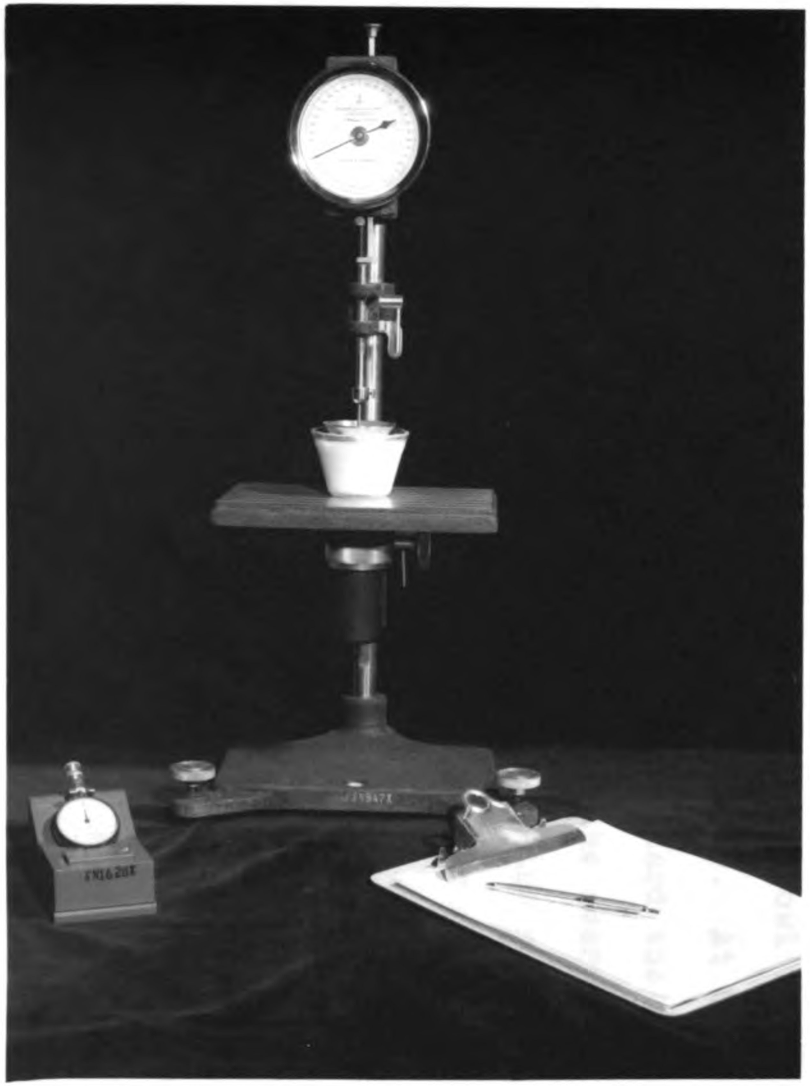
Penetration

Gel strength was determined by a Micrometer Adjustment Penetrometer[1] equipped with a 35-gram grease cone attachment[2]. Each sample was placed on a level platform directly beneath the cone attachment, with the point of the cone just touching the surface of the custard. The cone was released for a period of 5 seconds and the depth of penetration recorded to the nearest 0.1 millimeter. Measurements were made both with the crust on (crust loosened from the edges of the cup) and the crust off (crust entirely removed). Two different samples were used for each of these measurements; one from an inside bake position and one from an outside bake position. Readings were recorded and averaged. Figure 2 shows the measurement of penetration after the release of the cone.

Per Cent Sag

In order to compare the firmness of the different custards, measurements of the height of the inverted sample before and after a specified time interval were made. The procedure used for this objective test was that described by Zabik (64). The apparatus shown in Figure 3 was used to

1 Arthur H. Thomas Co.
2 Precision Scientific Co. - Cat. No. 73525



[illegible] 30-gm cone [illegible]

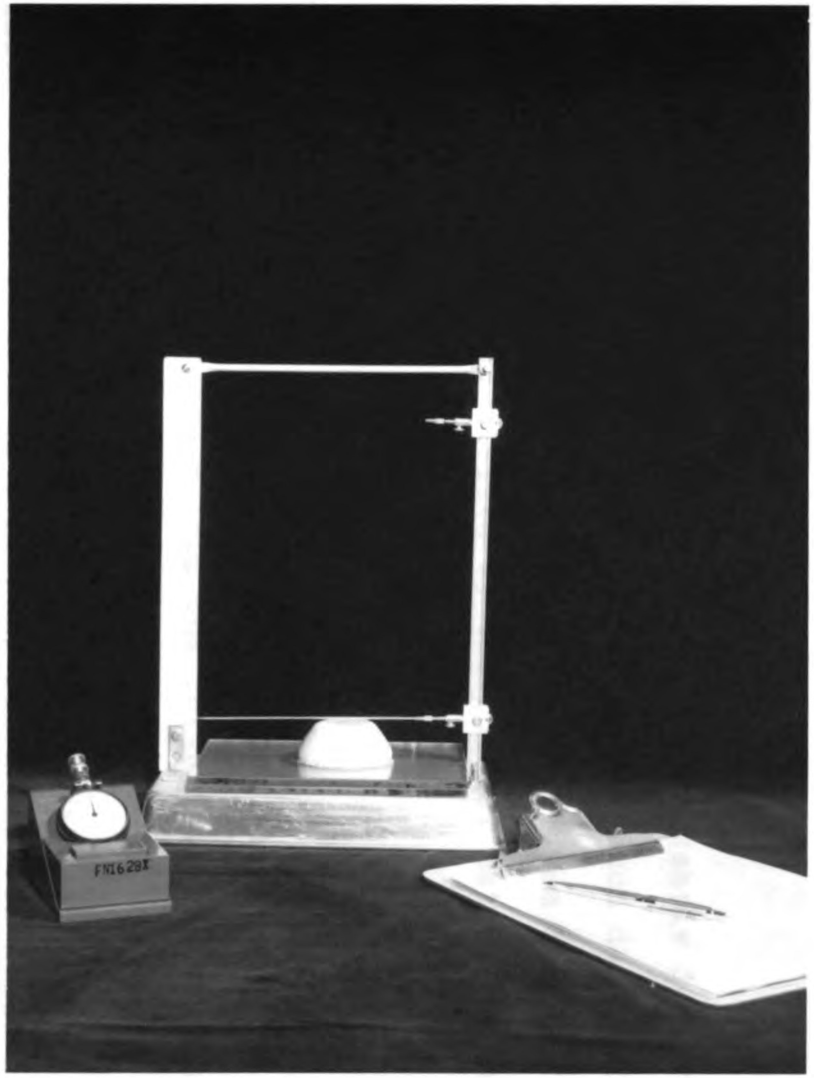


Figure 5. Apparatus for height measure-
ment of free-standing inverted
[illegible]

minimize damage to the gel structure of the sample during testing and to facilitate the collection of such data. The per cent sag for each sample was calculated from the difference between readings divided by the initial height of the inverted custard.

Syneresis

The method of Miller et al. (49) was used to determine the weight of the drainage from the custards. The equipment for this test is shown in Figure 4.

The baked custard with the crust intact was loosened carefully and inverted on fine wire screening (15 wires per inch) which had been placed over a weighed Petri dish. The assembly was immediately covered with a glass bowl to prevent evaporation and allowed to stand one hour. At the end of this period, the wire screen with the custard was removed and the weight of the drainage recorded to the nearest 0.1 gram. Per cent drainage was calculated from the ratio of the weight of the drainage to the weight of the sample before inversion.

pH

The pH of 50 ml of the fluid custard mix was recorded. The pH of the baked custard was determined after thoroughly blending one custard (approximately 130 c.c.) in a Waring Blender for one minute. All samples for the pH determinations were at room temperature (22°-25°C) and the

Figure 4. Equipment used for drainage weight determinations from free-standing inverted [illegible] custard.

measurements were made on a Beckman Zeromatic pH meter with a glass electrode and a saturated calomel electrode.

Statistical Methods

The data obtained from the subjective and objective tests were evaluated by the use of two computer programs on the CDC 3600 computer at the Michigan State University Computer Center. The FACREP Routine - Option 1 (one-way factorial with replications) was used to calculate analyses of variance and the CORE Routine was used to calculate simple correlations. Significant differences among variables were evaluated through use of the Studentized range tables (17). An illustration of the Studentized range calculations for one of the quality factors is shown in the Appendix, pages 97, and 98.

Correlation coefficients were calculated on the following pairs of items: penetrometer readings (crust off) versus per cent sag, penetrometer readings (crust off) versus consistency, per cent sag versus consistency, per cent drainage versus syneresis score, texture versus syneresis, crust color versus crust flavor, inside color versus inside flavor, crust color versus inside color, crust flavor versus inside flavor, inside flavor versus aroma, and consistency versus texture.

RESULTS AND DISCUSSION

The baked custards prepared from the nine possible combinations of three different peach colors and three levels of peach flavor were evaluated by subjective and objective tests. The identifying code for the combinations of colors and flavor levels used as treatment variables is as follows:

Variable	Color - Flavor Combination
A	Light color, low flavor level
B	Light color, medium flavor level
C	Light color, high flavor level
D	Medium color, low flavor level
E	Medium color, medium flavor level
F	Medium color, high flavor level
G	Dark color, low flavor level
H	Dark color, medium flavor level
I	Dark color, high flavor level
CONTROL	No added color, no added flavor

The scores obtained from the objective and subjective tests were analyzed by a one-way analysis of variance and by the Studentized multiple range test (17) when significant differences were found in the analysis of variance.

The mean taste panel scores and objective test readings for each replication of the baked custard variables and the standard deviations of the means are given in the tables accompanying the discussion of the results for each of the quality factors.

Subjective Tests

Crust Color

The mean scores and standard deviations for crust color are listed in Table 1. Analysis of variance of these data (Table 2) revealed significant differences in crust color attributable to the treatments. Comparison of treatment means indicated custard F scored significantly higher than custards A, I, H, B, and C at the 1 per cent level of probability and, in addition, significantly higher than custard G at the 5 per cent level of probability. Custards F, D, and E were not significantly different at the 5 per cent level of probability, indicating for crust color the medium peach color was equally acceptable regardless of the flavor level used. Custards A, D, and G (low flavor level) were not significantly different at the 1 per cent level of probability, indicating for crust color the low level of flavor was acceptable, regardless of the peach color used. However, the effect of flavor on color does not appear to be consistent.

The judges indicated the crusts of the light colored custards (A, B, and C) were too yellow, too pale, too light, and unappetizing. This objectionably light crust color accounted for the low scores assigned custards B and C but does not explain the higher score given to custard A. The higher score for custard A (light color, low flavor level) may have been due to first sample bias since this sample was

Table 1. Mean Scores and Standard Deviations for Crust Color.

Variable	Replications						Grand	
	1	2	3	4	5	6	Mean	S.D.
A[1]	5.14[2]	4.83	5.00	5.29	4.43	4.83	4.92±0.30	
B	3.57	3.43	3.57	4.00	4.00	3.57	3.69±0.25	
C	3.71	3.43	3.50	3.86	3.86	3.71	3.68±0.18	
D	5.00	5.14	5.00	5.57	5.29	5.71	5.29±0.30	
E	4.71	5.83	5.50	5.29	4.86	5.14	5.22±0.41	
F	5.57	5.71	6.00	5.71	5.29	5.33	5.60±0.27	
G	4.86	4.86	4.57	5.29	5.86	5.14	5.10±0.45	
H	4.29	4.43	4.83	4.57	4.86	4.67	4.61±0.22	
I	4.71	5.00	5.00	5.14	4.43	4.57	4.81±0.28	

[1] Refer to code on page 44 for variable identification.

[2] Mean score of 7 judges' evaluations of 1 replication of each variable.

Table 2. Analysis of Variance for Crust Color.

Source of Variance	Degrees of Freedom	Mean Square	F Ratio
Treatment means	8	2.7569	29.41**
Error	45	0.0937	
Total	53		

** Significant at 1 per cent level of probability.

Duncan's Studentized Multiple Range Test[1]

1% Level:

C	B	H	I	A	G	E	D	F
3.68	3.69	4.61	4.81	4.92	5.10	5.22	5.29	5.60
—	—				—	—	—	—
			—	—	—	—	—	
		—	—	—	—			

5% Level:

C	B	H	I	A	G	E	D	F
—	—	—	—	—		—	—	—
				—	—	—	—	
			—	—	—			

1 Means underscored by the same line are not significantly different (17).

always evaluated first whenever it was served.

The dark colored custards (G, H, and I) scored lower than the medium colored custards, although treatment H was the only one of the three that scored significantly lower than any of the medium colored custards (D, E, and F). The judges indicated the crusts of the dark colored custards were too red, too dark, and more orange colored than peach.

It was observed that the crust color was consistently darker than the inside color for all the variables and the baking procedure did not produce browning of the crust for any of the samples regardless of the peach color used. Figure 5, page 49, illustrates crust colors for the three different peach colors used in the study.

Crust Tenderness

The mean scores and standard deviations for crust tenderness are listed in Table 3. Analysis of variance of these data revealed no significant difference in the crust tenderness of the nine treatment variables.

Crust Flavor

Table 4 lists the mean scores and the standard deviations for crust flavor. The individual custards were significantly different for crust flavor only at the 5 per cent level of probability as shown by the analysis of variance, Table 5. Comparison of the variables by the Studentized multiple range method indicated custards F, G, and D scored

Figure 5. Three different peach colors in baked custards (crust on)[1].

Figure 6. Three different peach colors in inverted baked custards[1].

[1] Left to right - light color, medium color, dark color.

Table 3. Mean Scores and Standard Deviations for Crust Tenderness.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	4.14[2]	4.33	5.17	6.00	5.43	4.67	4.96±0.71
B	5.57	4.57	5.29	5.43	5.29	5.43	5.26±0.36
C	5.00	5.00	5.67	5.43	5.57	6.00	5.45±0.39
D	5.71	5.71	4.50	5.71	5.86	6.14	5.61±0.57
E	4.00	5.67	5.50	6.00	6.14	5.86	5.53±0.78
F	5.00	5.29	5.57	5.57	5.29	5.50	5.37±0.22
G	4.86	5.14	5.29	5.29	5.71	5.86	5.36±0.37
H	5.14	4.86	5.67	5.14	5.43	5.50	5.29±0.30
I	4.43	5.33	5.33	5.71	5.14	5.57	5.25±0.45

1 Refer to code on page 44 for variable identification.

2 Mean score of 7 judges' evaluation of 1 replication of each variable.

Table 4. Mean Scores and Standard Deviations for Crust Flavor.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	4.29[2]	4.67	5.17	5.71	5.43	4.67	4.99±0.54
B	4.43	5.00	4.43	4.57	5.00	4.86	4.72±0.27
C	4.57	4.86	5.33	5.14	4.57	4.86	4.89±0.30
D	4.57	5.14	5.33	5.71	5.57	5.43	5.29±0.40
E	5.00	5.17	5.00	5.29	5.57	5.43	5.24±0.23
F	5.14	5.43	5.43	5.57	5.43	5.50	5.42±0.15
G	4.43	4.71	5.43	5.57	6.14	5.71	5.33±0.64
H	5.14	5.00	5.00	5.00	5.00	5.83	5.16±0.33
I	5.14	4.50	5.50	5.14	4.86	4.14	4.88±0.49

[1] Refer to code on page 44 for variable identification.

[2] Mean score of 7 judges' evaluation of 1 replication of each variable.

Table 5. Analysis of Variance for Crust Flavor

Source of Variance	Degrees of Freedom	Mean Square	F Ratio
Treatment means	8	0.3514	2.17*
Error	45	0.1619	
Total	53		

* Significant at 5 per cent level of probability.

Duncan's Studentized Multiple Range Test[1]

5% Level;

B	I	C	A	H	E	D	G	F
4.72	4.88	4.89	4.99	5.16	5.24	5.29	5.33	5.42

(Underscoring: I through F by one line; B through E by a second line.)

[1] Means underscored by the same line are not significantly different (17).

significantly higher than custard B at the 5 per cent level of probability.

Panel members' comments indicated the crust flavor for custard B (light color, medium flavor level) was too weak, artificial, bitter, and slightly off-flavor. These results indicate the possibility of a "halo effect" of crust color impression on crust flavor judgments since custards D and G were low flavor level, medium and dark color respectively, and scored higher than custard B which was medium flavor level but light color. It was also noted the flavor was more concentrated in the crust than in the inside portion of the custard.

Inside Color

The mean scores and the standard deviations for inside color are listed in Table 6. Analysis of variance of these data (Table 7) revealed significant differences for inside color at the 1 per cent level of probability. Comparison of treatment means indicated custard G scored significantly higher than custards A, B, and C (light color) at the 1 per cent level of probability and, in addition, significantly higher than custard E at the 5 per cent level of probability.

Custards D, E, F, G, H, and I were not significantly different at the 1 per cent level of probability, indicating for inside color, the medium and the dark peach colors were equally acceptable regardless of the flavor level used. Custards A, B, and C contained the light peach color and scored

Table 6. Mean Scores and Standard Deviations for Inside Color.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	4.29[2]	4.83	4.83	4.71	4.00	4.83	4.58±0.35
B	4.29	3.86	3.86	4.00	3.57	4.00	3.93±0.24
C	4.29	3.86	4.17	3.57	3.57	3.86	3.89±0.30
D	4.86	5.14	5.17	5.57	5.29	5.29	5.22±0.23
E	4.71	5.33	5.17	5.00	4.71	5.29	5.04±0.28
F	5.00	5.00	5.57	5.43	5.14	5.50	5.27±0.26
G	5.71	5.29	5.14	5.43	5.86	5.29	5.45±0.28
H	4.86	4.86	5.00	5.29	5.29	5.33	5.11±0.22
I	5.14	5.17	4.83	5.29	5.14	5.14	5.12±0.15

1 Refer to code on page 44 for variable identification.

2 Mean score of 7 judges' evaluations of 1 replication of each variable.

Table 7. Analysis of Variance for Inside Color.

Source of Variance	Degrees of Freedom	Mean Square	F Ratio
Treatment means	8	2.0232	29.53**
Error	45	0.0685	
Total	53		

** Significant at 1 per cent level of probability.

Duncan's Studentized Multiple Range Test[1]

1% Level:

C	B	A	E	H	I	D	F	G
3.89	3.93	4.58	5.04	5.11	5.12	5.22	5.27	5.45

(Underscored together: C–B; E–H–I–D–F–G)

5% Level:

C	B	A	E	H	I	D	F	G

(Underscored together: C–B; H–I–D–F–G; E–H–I–D–F)

1 Means underscored by the same line are not significantly different (17).

significantly lower for inside color than all the other custards. The judges indicated the inside colors of the custards with the light color (A, B, and C) were too pale, too light, and too yellow for a peach color in baked custards.

It was observed the inside color was consistently lighter than the crust color for all variables. Custards B and C were scored significantly lower than all other custards for both crust color and inside color at the 1 per cent level of probability. Figure 6, page 49, illustrates inside colors for the three different peach colors used in the study.

Aroma

Table 8 shows the mean scores and the standard deviations for aroma. The analysis of variance showed no significant difference for aroma among the nine treatment variables at the 5 per cent level of probability.

Aroma in custards is a factor often difficult to evaluate. In this study the aroma seemed to be more difficult to evaluate if the crust had been removed from the custard for several minutes. The descriptive terms indicated frequently on the judges' score sheets for all of the treatment variables were: no peach aroma, too weak, and "eggy". It appears the addition of the three levels of peach flavor used in this experiment did not contribute to the peach aroma of any of the baked custards.

Table 8. Mean Scores and Standard Deviations for Aroma.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	4.14[2]	4.00	4.00	4.00	4.43	3.67	4.04±0.25
B	4.14	4.57	3.71	4.86	4.29	4.29	4.31±0.39
C	4.43	3.71	4.33	4.29	4.14	4.29	4.20±0.26
D	3.71	3.86	4.33	4.29	4.14	4.29	4.10±0.26
E	4.14	4.83	4.50	4.29	3.86	4.43	4.34±0.33
F	4.14	4.57	4.14	4.29	4.29	4.33	4.29±0.16
G	4.29	3.43	4.14	4.14	4.86	4.29	4.19±0.46
H	3.57	4.00	4.17	4.71	4.29	5.17	4.32±0.56
I	3.86	4.50	4.67	4.57	4.29	4.71	4.43±0.32

1 Refer to code on page 44 for variable identification.

2 Mean score of 7 judges' evaluations of 1 replication of each variable.

Inside Flavor

The mean scores and standard deviations for inside flavor are given in Table 9. No significant difference at the 5 per cent level of probability was indicated by analysis of variance of the inside flavor scores. The high standard deviation for custard A may have been caused by the low score for the first replication, the first custard the taste panel evaluated in this experiment.

Custard I received the highest mean score for inside flavor, however it was not significantly higher than the other custards. Custard C (light color, high flavor level) received the lowest mean score for inside flavor, indicating the judgments for inside flavor were influenced by impressions of the color. On the average, the group of custards with the dark color (G, H, and I) received the highest score for inside flavor. Treated as a group, it seems that the dark color may have exerted some "halo effect" on the inside flavor.

When comparing the inside flavor scores with the crust flavor scores (which were significantly different at the 5 per cent level of probability), it should be pointed out some of the panel members indicated the flavor appeared to be concentrated in the crust of the custards.

The taste panel members indicated the inside flavor of all the custards was too weak, "eggy", and artificial. All of the custards contained the same amount of sugar but

Table 9. Mean Scores and Standard Deviations for Inside Flavor.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	3.14[2]	4.17	4.33	4.29	4.57	4.33	4.14±0.51
B	4.29	4.14	4.29	4.00	4.43	4.14	4.22±0.15
C	4.14	4.14	4.00	4.29	3.86	4.14	4.10±0.15
D	3.86	3.86	4.33	4.29	4.71	4.86	4.32±0.42
E	3.71	4.50	5.00	4.57	4.71	4.57	4.51±0.43
F	3.86	4.86	4.43	4.86	4.57	4.67	4.54±0.37
G	4.29	3.86	4.71	4.86	4.71	4.71	4.52±0.38
H	4.71	4.29	4.71	4.57	4.14	5.17	4.51±0.39
I	4.57	4.33	5.00	4.71	5.14	4.43	4.70±0.32

1 Refer to code on page 44 for variable identification.

2 Mean score of 7 judges' evaluation of 1 replication of each variable.

judgments on the sweetness of the interior custard varied considerably among judges. For all nine variable treatments one panel member indicated the inside flavor was too sweet while another member indicated it was not sweet enough. The panel member who indicated the custards were too sweet had a low threshold for sucrose (0.015M) and the panel member who indicated the custards were not sweet enough had a high threshold for sucrose (0.035M) as determined by taste threshold studies conducted at the beginning of this experiment.

Consistency

Table 10 shows the mean scores and standard deviations for consistency. Analysis of variance of the scores for consistency indicated there was no significant difference at the 5 per cent level of probability. Therefore, consistency showed no effect due to treatment.

Texture

The mean scores and standard deviations for texture are listed in Table 11. There was no significant difference at the 5 per cent level of probability as indicated by analysis of variance.

The high standard deviations for custards C, D, and G may have been caused by the low scores in replications 2, 3, and 4 where the panel members indicated the interior texture was not smooth and the custards contained several holes. These custards were baked to the same end temperature as all

Table 10. Mean Scores and Standard Deviations for Consistency.

Variable	Replications						Grand Mean S.D.
	1	2	3	4	5	6	
A[1]	5.71[2]	5.83	5.33	5.57	5.43	5.33	5.53±0.21
B	5.29	4.86	5.57	5.14	5.57	5.71	5.36±0.32
C	5.86	5.57	4.33	5.29	5.71	5.43	5.37±0.55
D	5.00	5.29	4.83	5.29	4.86	5.86	5.19±0.39
E	5.00	5.50	5.67	5.14	5.43	5.57	5.39±0.26
F	5.57	5.86	6.00	5.29	5.29	5.50	5.59±0.29
G	5.43	5.14	5.57	5.43	5.43	5.43	5.41±0.14
H	4.71	5.29	5.00	5.14	5.29	5.33	5.13±0.24
I	5.14	5.67	5.83	5.71	5.86	5.86	5.68±0.28

[1] Refer to code on page 44 for variable identification.

[2] Mean score of 7 judges' evaluations of 1 replication of each variable.

Table 11. Mean Scores and Standard **Deviations for Texture.**

Variable	Replications						Grand Mean S.D.
	1	2	3	4	5	6	
A[1]	4.00[2]	5.50	4.50	5.00	4.57	3.67	4.54±0.66
B	5.43	4.86	6.00	4.00	4.57	5.14	5.17±0.77
C	6.14	3.86	3.33	4.00	5.86	4.71	4.65±1.14
D	6.00	3.57	3.83	4.14	4.43	5.57	4.59±0.98
E	4.43	4.67	4.67	4.00	5.86	4.29	4.65±0.64
F	5.57	6.00	5.43	4.86	5.43	4.00	5.05±0.75
G	5.29	6.14	5.71	3.57	5.86	5.43	5.33±0.92
H	5.43	4.14	3.67	4.71	4.57	4.00	4.42±0.62
I	4.14	4.17	4.33	4.29	4.71	5.14	4.46±0.39

[1] Refer to code on page 44 for variable identification.

[2] Mean score of 7 judges' evaluations of 1 replication of each variable.

other custards and the time required to reach 86°C was within the range of times for all other custards. Examination of the baking records does not reveal the reason for these high standard deviations.

Syneresis

Table 12 lists the means scores and standard deviations for the syneresis scores. Analysis of variance indicated no significant difference at the 5 per cent level of probability. The high standard deviation for custard C may have been caused by the low score for replication 3 and the relatively high scores for replications 1 and 5. The texture score for these replications of custard C showed similar variation. On scoring texture, the taste panel indicated this custard contained some holes and therefore a greater amount of syneresis would be expected.

Objective Tests

Penetration

The depth to which the penetrometer cone penetrated the baked custards was used as a measurement of the firmness of the custards. The mean penetrometer values with the crust on and with the crust off and the differences in the mean penetrometer values (crust off minus crust on) are included in Tables 13, 14, and 15 respectively.

Analyses of variance of the penetrometer values (from which the values of the control were excluded) indicated

Table 12. Mean Scores and Standard Deviations for Syneresis.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	5.00[2]	6.00	4.83	5.86	4.71	5.00	5.23±0.55
B	5.86	6.14	5.86	4.71	5.14	5.43	5.52±0.53
C	5.86	4.57	4.00	4.71	6.29	5.57	5.17±0.88
D	5.71	5.00	4.83	5.14	5.14	6.14	5.33±0.50
E	4.86	5.67	5.33	4.29	6.14	5.29	5.26±0.64
F	5.29	6.00	5.71	5.71	5.00	5.17	5.48±0.38
G	5.71	6.14	5.57	4.57	6.29	5.43	5.62±0.61
H	5.43	4.71	4.50	5.71	4.71	5.00	5.01±0.47
I	4.57	5.33	5.17	5.43	5.29	5.86	5.28±0.42

1 Refer to code on page 44 for variable identification.

2 Mean score of 7 judges' evaluations of 1 replication of each variable.

Table 13. Mean Penetrometer Values and Standard Deviations on Baked Custards with the Crust On. (Values in millimeters).

Variable	Replications						Grand Mean S.D.
	1	2	3	4	5	6	
A[1]	28.0[2]	27.6	29.2	28.0	28.7	28.6	28.4±0.59
B	27.6	27.3	26.7	27.2	27.7	28.1	27.4±0.48
C	27.9	28.1	28.9	26.7	27.3	26.5	27.6±0.91
D	27.1	29.4	28.5	29.6	28.6	27.0	28.4±1.11
E	28.0	29.0	28.6	27.2	26.9	26.5	27.7±0.99
F	26.9	27.8	27.4	28.0	26.9	27.7	27.5±0.47
G	27.6	27.1	27.3	27.0	26.4	28.1	27.3±0.53
H	26.8	28.4	27.0	27.1	28.5	28.4	27.7±0.81
I	26.9	28.3	28.4	27.8	27.9	27.7	27.8±0.54
CONTROL	26.3	26.8	27.5	28.0	27.1	28.1	27.3±0.70

1 Refer to code on page 44 for variable identification.

2 Mean score of 2 evaluations of 1 replication of each variable.

Table 14. Mean Penetrometer Values and Standard Deviations on Baked Custards with the Crust Off. (Values in millimeters).

Variable	Replications						Grand Mean S.D.
	1	2	3	4	5	6	
A[1]	29.8[2]	29.1	29.9	30.1	31.0	30.9	30.1±0.72
B	29.2	30.6	29.8	30.3	30.9	30.2	30.2±0.60
C	31.5	31.2	33.5	30.2	30.4	29.9	31.1±1.32
D	29.1	32.3	31.1	31.1	31.6	30.1	30.9±1.13
E	30.1	31.0	32.3	30.5	30.1	30.5	30.8±0.83
F	30.3	30.7	31.1	31.1	29.8	29.7	30.5±0.62
G	31.7	28.8	31.2	29.9	29.1	30.4	30.2±1.14
H	31.0	31.1	30.0	30.0	29.6	29.6	30.2±0.67
I	31.3	30.2	31.8	28.2	30.8	30.4	30.5±1.25
CONTROL	30.0	30.4	30.7	29.7	32.4	30.6	30.6±0.94

1 Refer to code on page 44 for variable identification.

2 Mean score of 2 evaluations of 1 replication of each variable.

Table 15. Mean Penetrometer Difference Values and Standard Deviations. (Values in millimeters).

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	1.8[2]	1.5	0.7	2.1	2.3	2.3	1.78±0.61
B	1.6	3.3	3.1	3.1	3.2	2.1	2.73±0.71
C	3.6	3.1	4.6	3.5	3.1	3.4	3.55±0.55
D	2.0	2.9	2.6	1.5	3.0	3.1	2.52±0.64
E	2.1	2.0	3.7	3.3	3.2	4.0	3.05±0.83
F	3.4	2.9	3.7	3.1	2.9	2.0	3.00±0.58
G	4.1	1.7	3.9	2.9	2.7	2.3	2.93±0.92
H	4.2	2.7	3.0	2.9	1.1	1.2	2.52±1.18
I	4.4	1.9	3.4	0.4	2.9	2.7	2.62±1.36
CONTROL	3.7	3.6	3.2	1.7	5.3	2.5	3.33±1.22

1 Refer to code on page 44 for variable identification.

2 Mean score of 2 evaluations of 1 replication of each variable.

there were no significant differences in firmness with the crust on, the crust off, or for the difference in the mean penetrometer values. There is no real explanation for the high standard deviations for several of the treatment variables since each value is an average of two readings for one replication (one inside bake and one outside bake). There was also the same number of front and back bakes for each treatment. When comparing the mean penetrometer values (crust on and crust off) for the nine treatment variables with those of the control custard, it does not appear the addition of the small amounts of food colors and peach flavors altered the firmness of the gel structure to any extent.

Differences between mean penetrometer values for samples with and without crust were recorded because it was thought this comparison might provide a possible measurement of resistance due to the crust for each of the treatment variables. No consistent trend appears with respect to the three different colors or the three levels of flavor.

Per Cent Sag

The mean per cent sag and standard deviations are listed in Table 16. Analysis of variance, excluding the control custard, showed no significant difference among the nine treatment variables.

The very high standard deviation for the control custard appears to be caused by the extremely high value for the sixth replication. It is felt that difficulty in

Table 16. Per Cent Sag and Standard Deviations of Baked Custards.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	6.40	4.58	7.52	4.92	15.42	4.80	7.27±4.15
B	6.69	6.99	6.84	7.34	7.71	9.30	7.48±0.97
C	8.89	7.52	7.71	5.04	7.16	6.99	7.22±1.26
D	9.52	9.52	7.91	7.52	5.17	14.68	9.05±3.19
E	9.09	4.92	7.52	7.71	5.04	9.09	7.23±1.86
F	6.69	4.80	10.52	7.71	7.52	7.34	7.43±1.85
G	7.52	7.34	4.92	4.92	7.34	6.99	6.51±1.24
H	6.99	4.92	4.80	4.92	6.69	10.00	6.39±2.02
I	7.16	7.34	7.16	7.52	7.52	4.80	6.92±1.05
CONTROL	4.80	7.16	7.71	7.16	6.99	20.00	8.97±5.50

1 Refer to code on page 44 for variable identification.

removing the custard from the cup caused this high value; this was evident with the sixth replication of custard D and the fifth replication of custard A.

The high standard deviations for all treatment variables and the difficulties encountered in removing the custard from the cup may indicate the method of performing the test for per cent sag used in this experiment is not suitable for use on conventional baked custards. The per cent sag test as conducted in this experiment has been used with satisfactory results in other types of gels (64). The per cent sag, as measured by a different technique, has been used successfully on baked custards by Mastic (44) and Miller et al. (49).

Syneresis

The mean per cent drainage values and the standard deviations are listed in Table 17. Analysis of variance of per cent drainage, excluding the control custard, revealed no significant difference.

The high standard deviations for custards D, E, and F were caused by the very high values in the second and third replications. These high values appeared to be connected with the difficulty involved in removing the custard from the cup. The custard would crack causing a greater amount of drainage. It must be noted that all but two of the standard deviations are higher than the corresponding means. These data do not represent true measurements of syneresis

Table 17. Per Cent Drainage and Standard Deviations of Baked Custards.

Variable	Replications 1	2	3	4	5	6	Grand Mean S.D.
A[1]	0.00	0.90	1.20	0.00	0.96	0.34	0.57±0.52
B	0.03	0.00	0.44	0.45	0.00	1.60	0.43±0.61
C	0.00	0.84	1.64	1.80	0.00	0.00	0.71±0.85
D	1.64	3.85	2.74	0.00	0.87	0.00	1.52±1.55
E	0.62	2.30	2.26	1.56	0.09	0.00	1.14±1.04
F	0.43	3.83	1.51	0.00	0.00	0.41	1.04±1.48
G	0.00	0.09	0.17	0.95	0.00	0.00	0.20±0.37
H	0.09	0.00	0.17	0.00	0.27	1.02	0.26±0.39
I	0.75	0.09	0.00	0.00	0.00	0.00	0.14±0.30
CONTROL	0.00	0.00	1.46	0.00	0.08	0.56	0.35±0.58

[1] Refer to code on page 44 for variable identification.

and no definite conclusions should be based on them.

pH Readings

The range of pH readings over six replications for the custard mix and for the baked custards are shown in Table 18. The ranges were so close no analysis of variance was carried out on the pH readings. In all cases the baked custards were more alkaline than the custard mix. This result is in accord with the findings reported by Logue (35), Lowe (38), and Miller et al. (49).

By comparison with the control custard, it appears that the addition of the small amounts of colors and flavors did not alter the acidity or alkalinity of the custard mixes or the baked custards under the conditions of this experiment.

Correlation between Selected Measurements

Correlation coefficients were calculated between selected objective measurements, between selected objective and subjective measurements and between selected subjective measurements. The results are shown in Table 19.

The penetrometer values (crust off) and the per cent sag values were compared to determine the relationship between these two objective measurements for firmness. There was no significant correlation between these two objective tests indicating that one or both of these tests may be unreliable as an objective method of determining firmness of baked custards.

Table 13. Range of pH Readings over Six Replications.

Variable	Range of pH for Custard Mix	Range of pH for Baked Custard
A[1]	6.90 - 7.00	7.01 - 7.10
B	6.92 - 7.00	7.01 - 7.10
C	6.90 - 6.99	7.05 - 7.10
D	6.90 - 6.99	7.05 - 7.10
E	6.90 - 7.00	7.02 - 7.10
F	6.90 - 7.00	7.02 - 7.10
G	6.90 - 7.00	7.01 - 7.10
H	6.90 - 7.00	7.01 - 7.10
I	6.90 - 7.00	7.01 - 7.10
CONTROL	6.90 - 7.00	7.02 - 7.10

1 Refer to code on page 44 for variable identification.

Table 19. Correlation Coefficients of Selected Measurements.

	r Value
I. Between Objective Measurements	
Penetrometer Values (Crust Off) vs. Per Cent Sag (Inverted, Crust On)	+0.0768
II. Between Objective and Subjective Measurements	
Penetrometer Values (Crust Off) vs. Consistency Scores	-0.1795
Per Cent Sag (Inverted, Crust On) vs. Consistency Scores	+0.0857
Per Cent Drainage (Inverted, Crust On) vs. Syneresis Scores	-0.2210
III. Between Subjective Measurements	
Crust Color vs. Crust Flavor	+0.5004**
Inside Color vs. Inside Flavor	+0.4334**
Crust Color vs. Inside Color	+0.3082**
Crust Flavor vs. Inside Flavor	+0.5649**
Inside Flavor vs. Aroma	+0.3592*
Texture vs. Syneresis	+0.3559**
Consistency vs. Texture	+0.3070*

** Significant at 1% level of probability.

* Significant at 5% level of probability.

Correlation coefficients were calculated on the taste panel scores for consistency with both the penetrometer values (crust off) and the per cent sag values to determine the reliability of these latter two tests. The results indicate there were no significant correlations between either of these two objective measurements and the subjective evaluation for firmness. Panel scores for syneresis were not correlated with per cent drainage values, indicating this objective measurement was not reliable. The results for firmness obtained with the penetrometer in this experiment are in accord with those of Bittner (3) and MacDougall (40), both of whom indicated that the curd tension meter is a better objective measure of gel strength than the penetrometer.

Table 19, part III shows comparisons between several of the factors scored by the taste panel. There were highly significant positive correlations between the following pairs of judges' scores: crust color and crust flavor, inside color and inside flavor, crust color and inside color, crust flavor and inside flavor. A "halo effect" of color impression on flavor judgment may be operating part of the time. The inside flavor and aroma scores were positively correlated at the 5% level of probability. The highly significant positive correlation existing between texture and syneresis scores indicates the texture scores increased as the syneresis scores increased, inferring that with a better texture (fewer holes) there was a smaller amount of drainage in the baked custards. The judges' scores for consistency and texture gave a positive correlation significant at the 5% level of probability.

SUMMARY AND CONCLUSIONS

The purpose of this investigation was to study the effect of the addition of the nine possible combinations of three different peach colors and three levels of peach flavor on the palatability and gel structure of standard baked custard.

The basic experimental formula consisted of constant proportions of reconstituted dried whole milk, fresh whole egg, and sucrose. Each of the nine treatment variables contained one of three peach colors - designated light, medium, and dark color - and one of three levels of peach flavor - designated low, medium, and high flavor level. A control custard having neither added color nor added flavor was used as a reference for the objective tests.

Six replications of each of the nine treatment variables were prepared and evaluated by subjective and objective methods. Preparation of the custard mix, addition of the colors and flavors, and baking procedure were standardized as much as possible. All samples were cooled to room temperature before objective and subjective evaluations.

Room temperature and relative humidity of the laboratory during preparation and testing were recorded. Time-temperature relationships during baking were recorded on a Brown Electronik Potentiometer High Speed Multiple Point Recorder.

The palatability of the baked custards was evaluated subjectively by a taste panel of 7 persons (4 women and 3 men) on nine characteristics: crust color, crust tenderness, crust flavor, inside color, aroma, inside flavor, consistency, texture, and syneresis. In rating the samples, a 7-point scale was used in which 7 was the highest possible score. Objective measurements included pH of the custard before and after baking, gel strength as indicated by the penetrometer (crust on, crust off) and per cent sag, and syneresis as indicated by per cent drainage.

Analysis of variance on the subjective scores for the nine treatment variables indicated there were no significant differences in six of the characteristics: crust tenderness, aroma, inside flavor, consistency, texture, and syneresis. Therefore it may be concluded that for these characteristics any of the nine variable treatments would be equally acceptable to the taste panel used in this experiment.

Significant differences among the nine treatment variables were found in the subjective scores for crust color (1% level of probability), inside color (1% level of probability), and crust flavor (5% level of probability). For crust color and inside color the light color custards as a group scored the lowest, and the medium color custards as a group scored the highest with the exception of custard G which received the highest mean score for inside color. This high inside color score for custard G indicates some of the taste panel members did not object to the dark inside color of the custard but they did object to the dark crust color. This reinforces the observation that the added color concentrates in the crust, making the crust darker in color than the inside portion of the custard.

For crust flavor, custard F (medium color, high flavor) scored the highest, followed by custards G and D, both containing the low flavor level and dark and medium colors, respectively. This may indicate influence of the "halo effect" of crust color impression on the judges' scores for crust flavor. Since the flavor seems to concentrate in the crust, it would not be unreasonable to find the low level of flavor rating high. In considering the three subjective characteristics which were significantly different, it appears that custard F (medium color, high flavor) was scored highest by this taste panel.

For inside flavor, custard I (dark color, high flavor) scored the highest, although the variable treatments were not significantly different. The medium color and high flavor level custard (custard F) scored second highest and custard G (dark color, low flavor) scored third. It should be noted the custard with high flavor level but low color (custard C) scored the lowest. As a group, the custards containing the dark color received the highest score for inside flavor. The evidence again seems to indicate the "halo effect" of color impression on flavor judgment.

It is evident the inside flavor scores were consistently lower than the crust flavor scores, reinforcing the observation that the flavor, as well as color, concentrated in the crust of the custard.

The results of the color and flavor scores indicate there were more differences in the color characteristics than in the flavor characteristics of the nine treatment variables.

Analyses of variance of the objective measurements indicated no significant difference in the nine variable treatments for gel strength and per cent drainage. High standard deviations for all of the objective measurements raise the question of the reliability and suitability of these objective evaluation methods for baked custards.

There was no significant correlation between penetrometer values (crust off) and per cent sag values, and no significant correlations between subjective and objective measurements for gel strength or for syneresis. These results may indicate the unreliability of the objective methods used.

Highly significant positive correlations were found between several selected subjective measurements. The highly significant positive correlations between crust color and crust flavor and inside color and inside flavor indicate the "halo effect" of color impression on flavor judgment.

Highly significant positive correlations were also found for crust color versus inside color, crust flavor versus inside flavor, and texture versus syneresis. Positive correlations at the 5% level of probability were found for inside flavor versus aroma and consistency versus texture.

LITERATURE CITED

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APPENDIX

Table 20. Colors and Flavors Used in Baked Custards for Objective Tests.

(Quantity for 1100 c.c. custard mix)

Variable	Color Solution #1[1]	Color Solution #2[1]	Color Solution #3[1]	Flavor #1[2]	Flavor #2[3]	Flavor #3[4]
	ml	ml	ml	ml	ml	ml
A	1.00	-	-	0.55	0.28	0.11
B	1.00	-	-	1.10	0.55	0.22
C	1.00	-	-	1.65	0.83	0.33
D	-	1.00	-	0.55	0.28	0.11
E	-	1.00	-	1.10	0.55	0.22
F	-	1.00	-	1.65	0.83	0.33
G	-	-	1.00	0.55	0.28	0.11
H	-	-	1.00	1.10	0.55	0.22
I	-	-	1.00	1.65	0.83	0.33

1 See page 91 for composition of color solutions.

2 Imitation Peach Extract No. 7442, Food Materials Corporation, Chicago 18, Illinois.

3 Imitation Peach Flavor with True Fruit F-4710, Givaudan Flavors Inc., New York 36, New York.

4 Flex-Sol Imitation Peach Concentrate F-4711, Givaudan Flavors Inc., New York 36, New York.

Table 21. Colors and Flavors Used in Baked Custards for Subjective Tests.

(Quantity for 1500 c.c. custard mix)

Variable	Color Solution #1[1] ml	Color Solution #2[1] ml	Color Solution #3[1] ml	Flavor #1[2] ml	Flavor #2[3] ml	Flavor #3[4] ml
A	1.36	-	-	0.75	0.38	0.15
B	1.36	-	-	1.50	0.75	0.30
C	1.36	-	-	2.24	1.13	0.45
D	-	1.36	-	0.75	0.38	0.15
E	-	1.36	-	1.50	0.75	0.30
F	-	1.36	-	2.24	1.13	0.45
G	-	-	1.36	0.75	0.38	0.15
H	-	-	1.36	1.50	0.75	0.30
I	-	-	1.36	2.24	1.13	0.45

1 See page 91 for composition of color solutions.

2 Imitation Peach Extract No. 7442, Food Materials Corporation, Chicago 18, Illinois.

3 Imitation Peach Flavor with True Fruit F-4710, Givaudan Flavors Inc., New York 36, New York.

4 Flex-Sol Imitation Peach Concentrate F-4711, Givaudan Flavors Inc., New York 36, New York.

Table 22. Description of Flavors Used.

Flavor	Composition	Solvent	Solubility	pH
Imitation Peach Extract No. 7442 (Food Materials Corporation)	Combination of natural oils such as orange oil and synthetic flavoring materials (23).	95% alcohol (23)	Completely soluble in alcohol; some of the materials not soluble in water (23).	6.0-7.5 (23)
Imitation Peach Flavor with True Fruit F-4710 (Givaudan Flavors Inc.)	Blend of synthetic ingredients with concentrated peach extract (29).	alcohol and water	Absolute alcohol and water	4.2 (16)
Flex-Sol Imitation Peach Concentrate (Givaudan Flavors Inc.)	An emulsion of oil soluble chemicals and gum arabic (29).	water	Not completely soluble in alcohol due to gum arabic (29). Soluble in water.	4.1 (16)

Table 23. Composition of Color Solutions.

Color Solution[1]	FD&C Red No. 4	FD&C Yellow No. 5
	mg	mg
#1 (Light)	330	220
#2 (Medium)	490	220
#3 (Dark)	730	660

[1] Powdered colors made up to 100 ml. solution with distilled water. pH of all three color solutions was 7.3.

Exhibit 1. Procedure for Preparation of Colored and Flavored Custard Mixes.

Preparation of fluid milk:

1. Remove one package of dried whole milk (504 grams) from refrigerator and allow to come to room temperature.

2. Weigh out 3496 grams tap water into aluminum saucepan and heat to 46°C.

3. Pour heated water into a 12-quart bowl of a Hobart Mixer[1] and add DWM.

4. Mix DWM and water on speed #1 for 30 seconds using the paddle attachment.

5. With a rubber spatula mix the milk by hand to break down any lumps.

6. Mix the milk an additional 30 seconds on speed #1.

7. Place the mixing bowl in a cold water bath to cool the milk rapidly to room temperature.

Preparation of basic custard mix:

1. Break 15 fresh, shell eggs into a 5-quart bowl of a Kitchen Aid Mixer[2].

2. Beat eggs for 3 minutes on speed #2 using a whip attachment and then for 1 minute on speed #4.

3. Weigh out 748 grams of blended egg into a 5-quart Kitchen Aid mixing bowl.

4. Add 391 grams of sugar to egg and blend egg-sugar mixture for 1 minute on speed #4 using the paddle attachment.

5. Pour egg-sugar mixture into a 12-quart Hobart mixing bowl.

6. Weigh out 3815 grams of the reconstituted whole milk and add to the egg-sugar mixture.

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[1] Hobart model A-200 mixer, The Hobart Mfg. Co., Troy, Ohio.

[2] Kitchen Aid K5-A mixer, The Hobart Mfg. Co., Troy, Ohio.

7. Mix the egg-sugar-milk mixture on speed #1 for 5 minutes using the paddle attachment.

8. Strain custard mix through a medium-fine, wire-mesh household strainer to remove any undissolved particles.

9. Divide custard mix into smaller portions in 5-quart stainless stèel bowls. Four portions of 2100 c.c. each for objective tests; three portions of 1500 c.c. each for subjective tests.

Addition of color and flavors:

1. Add color solution to custard mix using a 1 ml. pipette.

2. Add flavors, one at a time, to custard mix using 1 ml. pipettes.

3. Mix the added color and flavors into the custard mix using a Kitchen Aid K5-A mixer with the paddle attachment on speed #1 for 2 minutes.

Exhibit 2. General Instructions for Peach Custard Taste Panel Members.

1. Please do not eat, smoke, or chew gum for 1/2 hour prior to the time of tasting.

2. Do not give any reactions, such as grimace, smile, or vocal expression as you evaluate the sample.

3. You will receive three custards, one at a time, to judge each day. All samples will be at room temperature. You are to evaluate one custard at a time and complete your scoring on that custard before another one is presented to you. There will be a separate score sheet for each custard. Since this is a color and flavor problem you will be receiving custards of different color and different levels of flavor. Remember to score each sample independently of the others.

4. Judge the nine factors in the order in which they are listed on the score sheet. Place a mark (X), using a red pencil, in the block which most nearly fits your evaluation rating of each sample. Be sure to score each of the factors listed on the score sheet and to mark (X) the appropriate descriptive term(s) for each factor you rate <u>4 or below</u>.

5. Between each sample eat some unsalted cracker and take a drink of the water provided.

6. This sheet will be given to you each day you score to remind you of the definitions and instructions below.

****

PALATABILITY FACTORS: DEFINITIONS AND INSTRUCTIONS

<u>Crust Color</u>. Evaluate the crust color of the custard as it appears in the custard cup. The crust color will always be more intense than the inside color.

<u>Crust Tenderness</u>. With your spoon, break through the crust in the center of the custard and evaluate the tenderness of a piece of the center crust.

<u>Crust Flavor</u>. Evaluate the flavor of a piece of crust taken from the center to the outside of the custard cup.

<u>Inside Color</u>. Spoon some of the custard onto the plate provided and evaluate the inside color.

Aroma. Evaluate aroma on the basis of a sniff obtained from the custard remaining in the custard cup.

Inside Flavor. Taste some of the custard in the cup (without crust) and evaluate the flavor.

Consistency. Spoon some of the custard from the cup onto the plate, cut through it with the edge of the spoon, and make an evaluation. The custard should hold its shape when spooned out but not make a brittle break when cut.

Texture. Look at the custard in the cup, at the bottom and around the sides. There should be no holes present. Taste the custard to determine smoothness.

Syneresis. Look at the custard remaining in the cup and on your plate. There should be little or no separation of the liquid from the gel structure.

CHECK THE SCORE SHEET TO MAKE SURE NO FACTORS HAVE BEEN OMITTED AND THE APPROPRIATE DESCRIPTIVE TERM(S) FOR EACH FACTOR SCORED 4 OR BELOW HAVE BEEN MARKED (X)

Exhibit 3. SCORE SHEET FOR PEACH CUSTARD

Judge______________ Code no.________

Date ______________

Score Key:
7 - Excellent
6 - Very good
5 - Good
4 - Medium
3 - Fair
2 - Poor
1 - Very poor

Instructions: In the appropriate columns, place a mark (X) for the score which best expresses your evaluation of that factor. For those factors scored 4 or below, mark (X) the descriptive terms which best describe the sample.

PALATABILITY FACTORS	SCORE VALUES 7	6	5	4	3	2	1	DESCRIPTIVE TERMS
CRUST COLOR								__Unappetizing __Too red __Too dark __Too yellow __Too pale __Other______
CRUST TENDERNESS								__Tough __Rubbery
CRUST FLAVOR								__Too strong __Bitter __Too weak __Artificial __Other______________
INSIDE COLOR								__Too dark __Too red __Too pale __Too yellow __Other ______________
AROMA								__Too strong __Perfumy __Too weak __Other______
INSIDE FLAVOR								__Too sweet __Bitter __Not sweet enough __Artificial __Too strong __Eggy __Too weak __Other_____
CONSISTENCY								__Too firm __Rubbery __Not firm enough __Brittle __Other ______________
TEXTURE								__Not smooth __Many holes __Several holes
SYNERESIS								__Slight syneresis __Pronounced syneresis

Exhibit 4. Sample Calculation of Studentized Multiple Range Test.

Based on data for Crust Color

General formula for standard deviation of the mean:

$$S_{\bar{x}} = \sqrt{\frac{s^2}{n}} \qquad \begin{aligned} s^2 &= \text{variance (error mean square)} \\ n &= \text{number of replications} \end{aligned}$$

Sample (see Table 2, page 47):

$$S_{\bar{x}} = \sqrt{\frac{0.0937}{6}} = 0.125$$

Studentized Multiple Range Values (1% level of probability)[1]:

2	3	4	5	6	7	8	9
3.82	3.99	4.10	4.17	4.24	4.30	4.34	4.37

Shortest Significant Ranges[2]:

(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
.48	.50	.51	.52	.53	.54	.54	.55

Crust Color Mean Scores:

Treatment variable:	C	B	H	I	A	G	E	D	F
Mean Score:	3.68	3.69	4.61	4.81	4.92	5.10	5.22	5.29	5.60

Any two means not underscored by the same line are significantly different. Any two means underscored by the same line are not significantly different (17).

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1 Duncan (17).

2 Shortest Significant Ranges = Studentized Multiple Range Values x $S_{\bar{x}}$. If the difference between any two scores exceeds the shortest significant range value, those scores are significantly different.

Conclusions:

Treatment variable F scored significantly higher than treatment variables A, I, H, B, and C.

Treatment variables D and E scored significantly higher than treatment variables H, B, and C.

Treatment variables G, A, I, and H scored significantly higher than treatment variables B and C.